TEMPERATURE GRADIENT IN THE EGG–LAYING ACTIVITIES OF THE QUEEN BEE.

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INTRODUCTION.

It is generally thought that the hive temperature at which the queen is stimulated to start her egg-laying activities in early spring is about 93 degrees F. One might gather from this that when brood-rearing has once been stimulated the above temperature is maintained in the brood nest, and that the queen is rather fixed in responding by egg-laying at any other than the temperature stated. It was because of some doubt concerning this idea that this study of the gradient in egg-laying was undertaken.

The writer wishes to express his appreciation to Professor Herbert Osborn for his helpful suggestions on this work.

APPARATUS.

The thermocouple method of taking temperatures lends itself admirably to this type of work. The use of these instruments avoids any abnormal reactions which might result in stimulating the colony and thus causing a higher temperature which was often the case in the old method of taking temperatures with mercuric thermometers. Also the readings are accurate and almost instantaneous.

A two pound package of bees with an untested queen was placed in a four frame vertical observation nucleus. Before any study was undertaken, the bees were left long enough so that they had become fully adjusted to their environment and had begun broodrearing. The four frame vertical observation nucleus consisted of four Hoffman frames placed one above the other. The sides of the observation nucleus were of glass. On Each side of each frame were three thermocouple junctions inserted through the glass, making six junctions for each frame and twenty-four for the entire nucleus. (See Fig. 1, for arrangements of the thermocouple junctions). This observation nucleus was placed in a dark room where the temperature was

quite constant. Red lights, to which bees made no abnormal response, afforded illumination for the worker to carry on his observations. An extension of the entrance of the observation nucleus was made which led to the outside of the building and thus allowed flight activities for the bees.

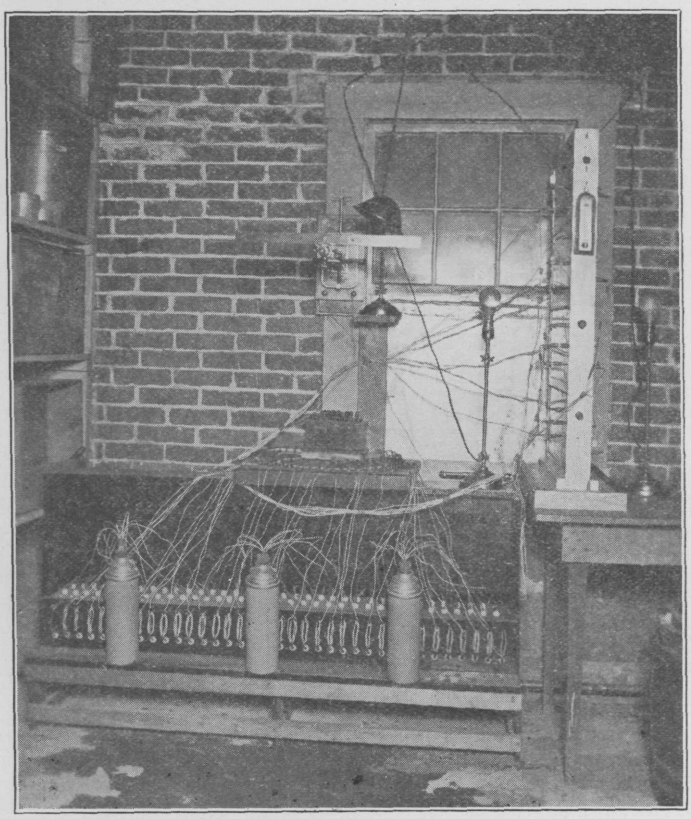

FIG. 1. GENERAL ARRANGEMENT OF APPARATUS WHEN STUDYING THE EGG LAYING ACTIVITIES OF THE QUEEN BEE.

GENERAL PROCEDURE.

Observations on this experment which were carried on in 1928 were begun on the morning of June 5th and continued through the evening of June 9th. These observations were arranged in three thirty-minute periods daily; one in the morning, one at noon, and one in the evening, so as to obtain a fairly accurate representation of what took place during each day.

In the study of the gradient in the egg-laying activity of the queen bee, observations were taken on the amount and position of the brood and the bees; the number of eggs laid by the queen; the exact position of these eggs, and the temperature of the region in which the eggs were laid. After these data had been gathered for the entire period, they were arranged in a temperature gradient table which started at 73 degrees F. and with intervals of 3 degrees (ie. 73-76-79 etc.) culminated at 94 degrees F. At these various temperatures, the number of eggs laid during the observation periods were tabulated (Table I). Fig. 2 gives a graphic representation of the tabulated data.

TABLE I.

INFLUENCE OF BROOD NEST TEMPERATURES ON THE EGG LAYING ACTIVITY OF THE QUEEN BEE.

TEMPERATURES DEGREES F.	71½° 73°	74½° 76°	etc. 79°	82°	85°	88°	91°	94°
Number of eggs laid by the queen.....	0	2	19	34	67	110	96	22

DISCUSSION.

As shown in the table, the egg-laying activity of the queen was carried on from 73 degrees F. to 94 degrees F. thus showing conclusively that after the queen has once started her egg-laying activities in the spring she is not absolutely confined in her egg-laying processes to a rather narrow range of temperatures. However, the temperature range is relatively very narrow at which she responds most actively to egg-laying, as shown in Table I. This region ranges from 88 degrees F. to 91 degrees F. It is interesting to note the gradual gradient from the optimum egg-laying temperature to the lowest egg-laying temperature. Of equal significance is the egg-laying gradient from the optimum temperature to the highest temperature recorded or 94 degrees F. A comparison of the gradient in egg-laying taking place from the optimum to the lowest temperature with that from the optimum to the highest temperature indicates that the fall of the gradient in egg-laying is

much greater in the latter than in the former. This is further substantiated in some observations already reported.*

During the observation period, other factors were recorded which must be given careful attention in order to make a clear diagnosis of the gradient in the egg-laying of the queen bee.

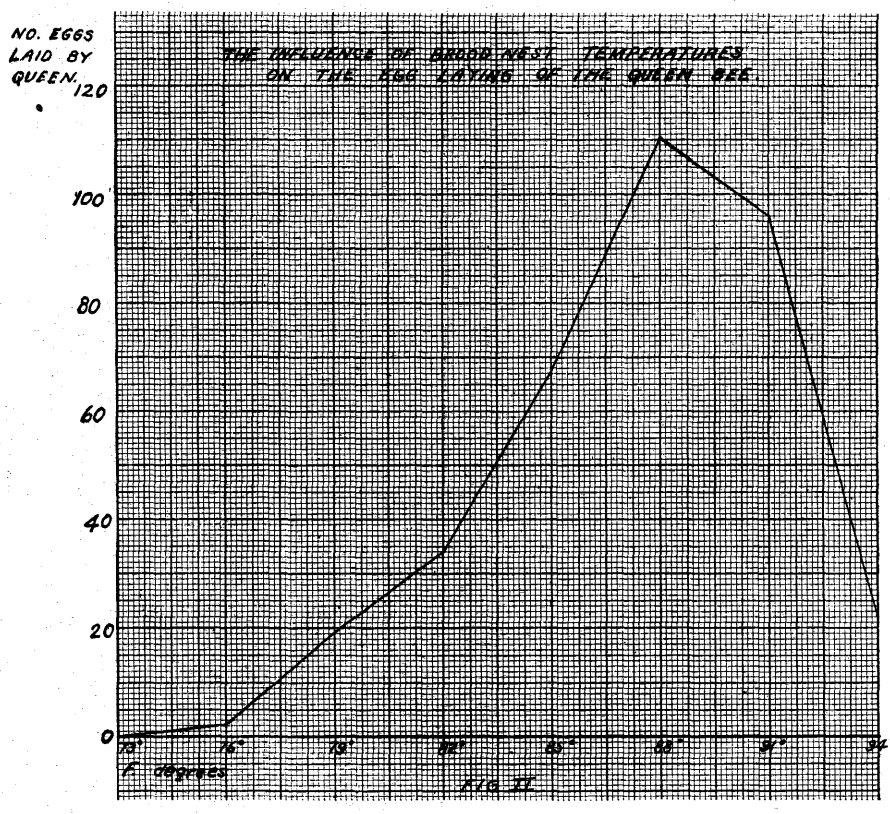

FIGURE 2.

The fact must not be overlooked that this experiment was conducted during the spring when brood-rearing is more intensive than at any other time of the year. When conditions are normal, as was the case in the colony used in this experiment, there is a rapid expansion of the brood-nest. Because of the ability of the queen for heavy egg-laying during

*Dunham, W. E. The Relation of Heat to Brood Rearing. Gleanings in Bee Culture. 57: 359–362. June, 1929.

the spring period, she not only keeps the area from which brood is emerging filled with eggs, but she also lays eggs on the outer region of the brood-nest, thus constantly increasing the area occupied with brood. It is quite evident that the warmest temperatures will occur in the central region of the brood-nest and that the cooler temperatures at which the queen will lay, will occur at the junction of that portion of the comb unoccupied with brood with that containing brood.* Thus it is obvious that when intensive brood-rearing is going on which results in a rapid expansion of the brood-nest, the gradient in egg-laying from the optimum temperature to the low extreme will cover a wide range.

Having made a detailed study of the egg-laying gradient for this particular period of the year, certain correlations are suggested. Nolan's work brings† out very conclusively that there are definite phases in the brood-rearing curve during different parts of a year. In brief, he found that there are three distinct phases of the curve, which are: the initial brood-rearing phase, the major brood-rearing phase, and the contraction brood-rearing phase. Following the latter is a broodless period.

The initial brood-rearing phase begins early in the spring and follows the broodless period which might be termed a semi-dormant phase. In comparing the amount of brood present at this time with the number of bees to care for it and maintain the other activities of the hive, it is obvious that the ratio of the number of bees to the amount of brood is very high. As a result, the temperature where the queen begins laying would be quite constant. This would mean, then, that the temperature gradient in egg-laying would be confined to a small area with a slight temperature range. However, as the brood-nest becomes more and more expanded during this initial brood-rearing period, the range in the temperature gradient in egg-laying would become increasingly greater. The reason for this is that, as the brood-nest is rapidly expanding, the ratio of the number of individual bees to care for the increasing brood area and carry on the other activities of the hive becomes less and less. When this ratio has reached its

*Dunham, W. E. The Influence of External Temperature on Hive Temperatures during the Summer. Journ. Econ. Ent., 22: 798–800. 1929.

†Nolan, J. W. The Brood Rearing Cycle of the Honey Bee. U. S. Dept. Agric. Bul. No. 1349.

extreme, the temperature gradient in egg-laying from the optimum temperature to the low temperature will reach its widest range. As the brood emerges, and the ratio of the number of individual bees to care for the brood and the duties of the hive increases, the range in the temperature gradient of egg-laying becomes increasingly less. Also correlated with the increasing number of bees in a hive is an increase of the temperature in the central upper portion of the brood area to more than the optimum temperature regardless of the activities of the bees which tend to hold the temperature rather constant. The fact must not be overlooked that some heat is given off by the brood due to its metabolic activity.

Another interesting correlation occurring during the initial brood-rearing period is the difference between weak and strong colonies in the temperature gradient in egg-laying. In weak colonies this gradient from the optimum temperature to the lowest temperature covers a wider range of degrees and is also extended over a longer period of time than is the case in strong colonies. Because of the small number of bees in weak colonies, the queen soon has the area of the hive filled with brood where the bees are able to maintain a favorable temperature. In such a case, because of the tendency for a rapid expansion of the brood-nest, the queen responds by laying in cooler temperatures than she would otherwise.

The recommendation of beekeeping experts to leave packing on colonies until weather conditions in the spring have become settled, also has a direct influence on the temperature gradient in the egg-laying of the queen bee. With this insulating layer around the hive, the bees are able to maintain the favorable egg-laying temperature over a larger area of the hive, than they could otherwise. This would result then in the temperature gradient in the egg-laying of the queen covering a narrower range from the optimum temperature to the lowest temperature than if the colonies were unprotected and consequently she would lay eggs at a much more rapid rate.

Another interesting phenomenon which takes place during the initial brood-rearing period is that, as one goes northward from the southern states, the intensity of brood-rearing becomes increasingly greater. It has been suggested that the intensity of brood-rearing increases as the length of the broodless period increases. The writer is not in accord with this belief but

attributes it to certain other conditions found in the northward regions.

The writer is of the opinion that if a queen were taken from a northern colony where the broodless period had been long and placed at the beginning of the initial brood-rearing period in a colony in the south, that the intensity of brood-rearing and magnitude of the initial brood-rearing curve would undoubtedly correspond very closely to that of other colonies in the south where the queens had been wintered over with the colony and the broodless period had been short. It has already been shown that if a queen from the south where the broodless period had been short were introduced at the beginning of the initial brood-rearing period to a colony in the north, the intensity in brood-rearing and the magnitude of the initial brood-rearing curve would correspond very closely to that of other colonies in the north where the queen had been wintered over with the colony. A good example of this is the practice among northern beekeepers of sometimes buying from the south, pound packages of bees with a tested queen. The bees are young and have never passed through a broodless period which eliminates any possible argument that over wintered bees factor in the magnitude of the initial brood-rearing curve in the north. However, the queen in order to be of a tested grade and shipped out this early in the season must have been reared the previous year and have passed through a southern winter where the broodless period is short. A package of bees with a tested queen which is shipped so that it begins brood-rearing about the same time as brood-rearing starts in northern colonies, begins brooding just as intensively and the final peak in the initial brood-rearing curve reaches the same magnitude as in northern colonies where the broodless period has been long. It is quite evident then that the length of the broodless period is not the determining factor in the magnitude of the initial brood-rearing curve but that there are other conditions that are present as one goes northward that are not present in the southern states which have a direct bearing on the magnitude of the initial brood-rearing phase. One of the important factors which has a direct bearing to some degree at least on the temperatures that occur within the hive must be external temperatures.

As one goes northward, the temperatures occurring in early spring when brood-rearing starts, increases gradually as the

season advances. Thus it requires a longer time before external temperatures occur which are as high or higher than the optimum egg-laying temperature. Because of these cooler conditions, even though the population of the colony increases, there is a longer time for the queen to lay on the lower scale of the optimum egg-laying temperature as well as at the optimum egg-laying temperature. Since the gradient is much slower on this side of the scale, it results in the fact that the initial brood-rearing curve will reach a high magnitude.

In the south one finds a reverse condition. The temperatures occurring in spring when brood-rearing starts, increase quite rapidly as time goes on and so in a short time external temperatures occur which are as high or higher than the optimum egg-laying temperature. Because of these higher temperatures along with the increased population of the hive, there is a large portion of the hive where the temperature is on the higher scale of the optimum egg-laying temperature. Since the gradient is much more rapid on this side of the scale, the initial brood rearing curve will not reach a high magnitude.